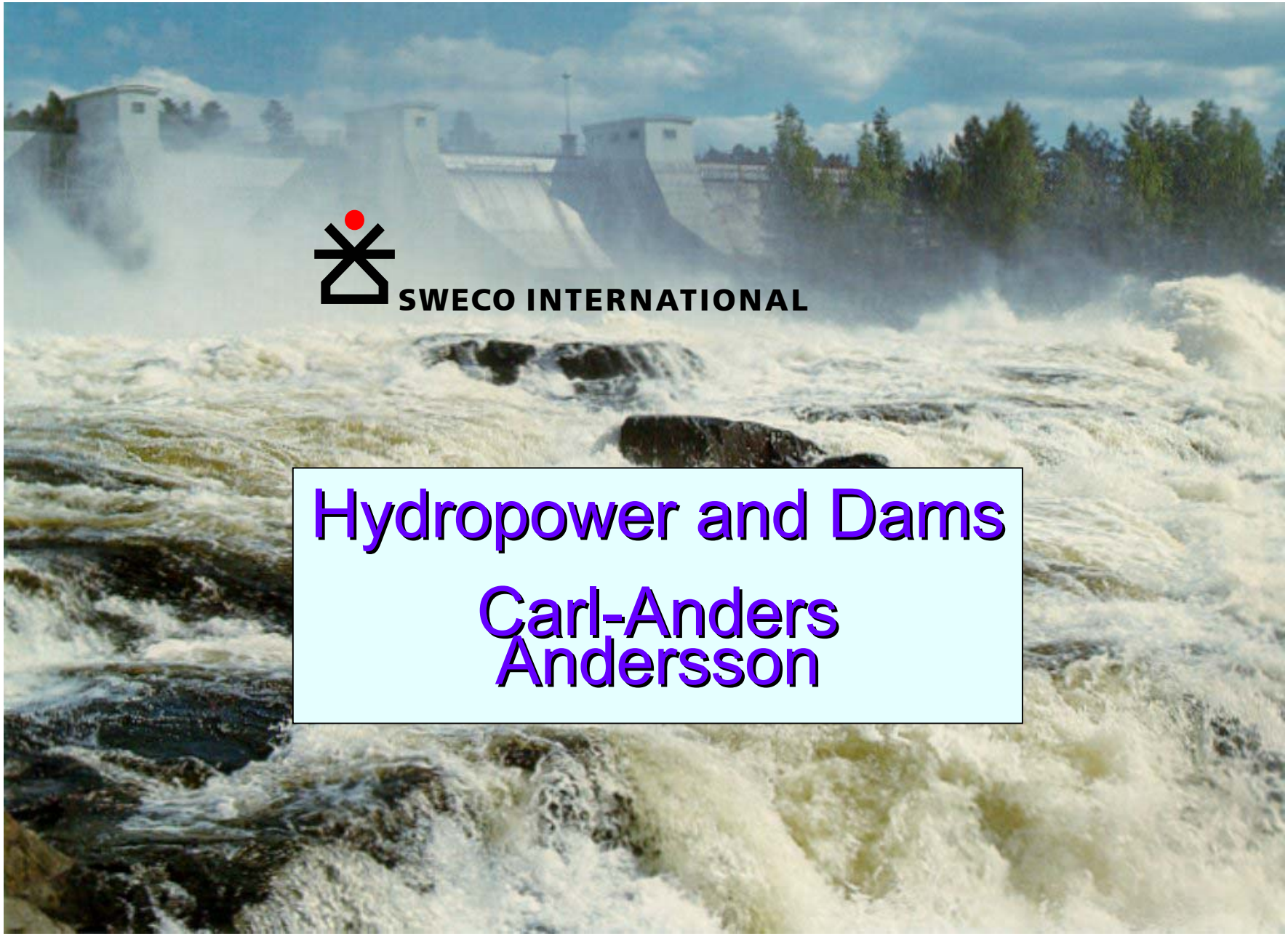
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Hydropower and Dams
Carl-Anders Andersson

Waterpower plants, Sweden

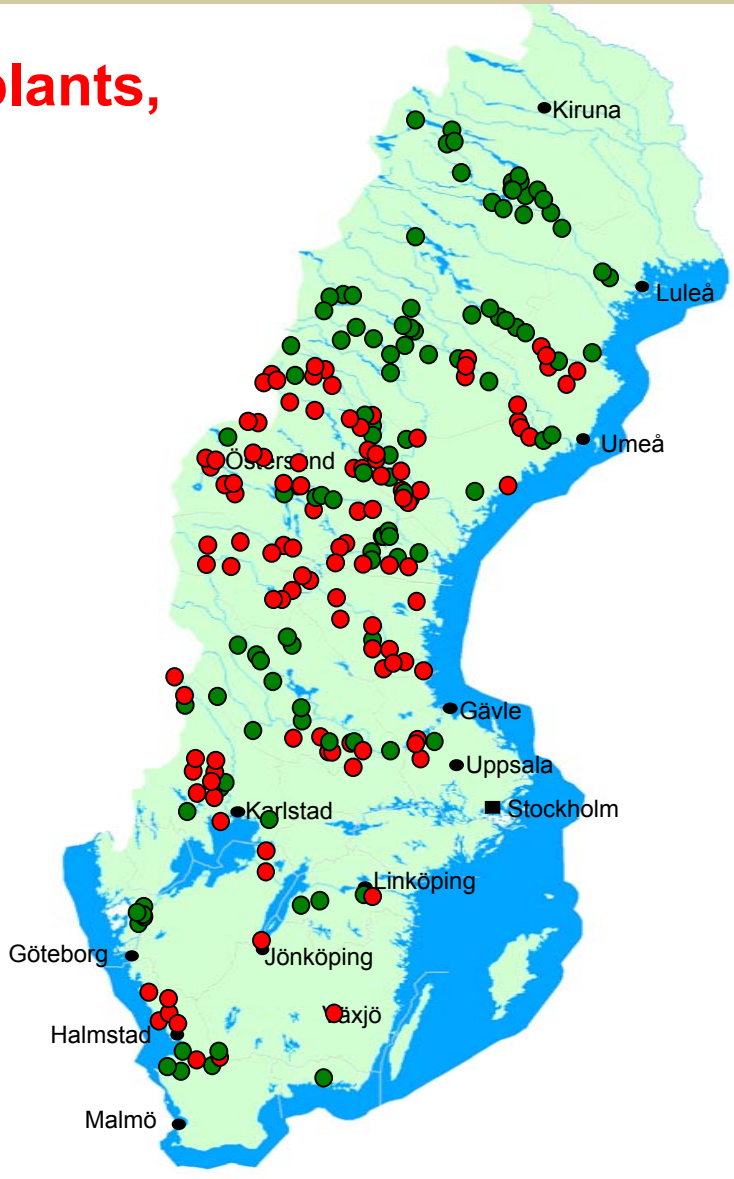
> 10 MW.

Total 197 plants

Total 14 845 MW.

Consultants:

- **SWECO**
- **Others**



Constructed

- **1900-1909**
- **1910-1919**
- **1920-1929**
- **1930-1939**
- **1940-1949**
- **1950-1959**
- **1960-1969**
- **1970-1979**
- **1980-1989**
- **1990-2000**

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Large and small hydropower schemes in Sweden

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High hydropower potential in many developing countries is a valuable energy asset

Each hydropower project is unique and requires specific considerations

The development of the hydropower potential should take into account:

- Multipurpose use of water, i.e. for human and industrial consumption, irrigation
- Environmental aspects, incl. socio-economical effects
- Safety
- Lifetime and sustainability

Design Aspects

NATURAL CONDITIONS

- Hydrology and climate
- Topography
- Geology
- Available materials for construction
- Sediment transport in the rivers

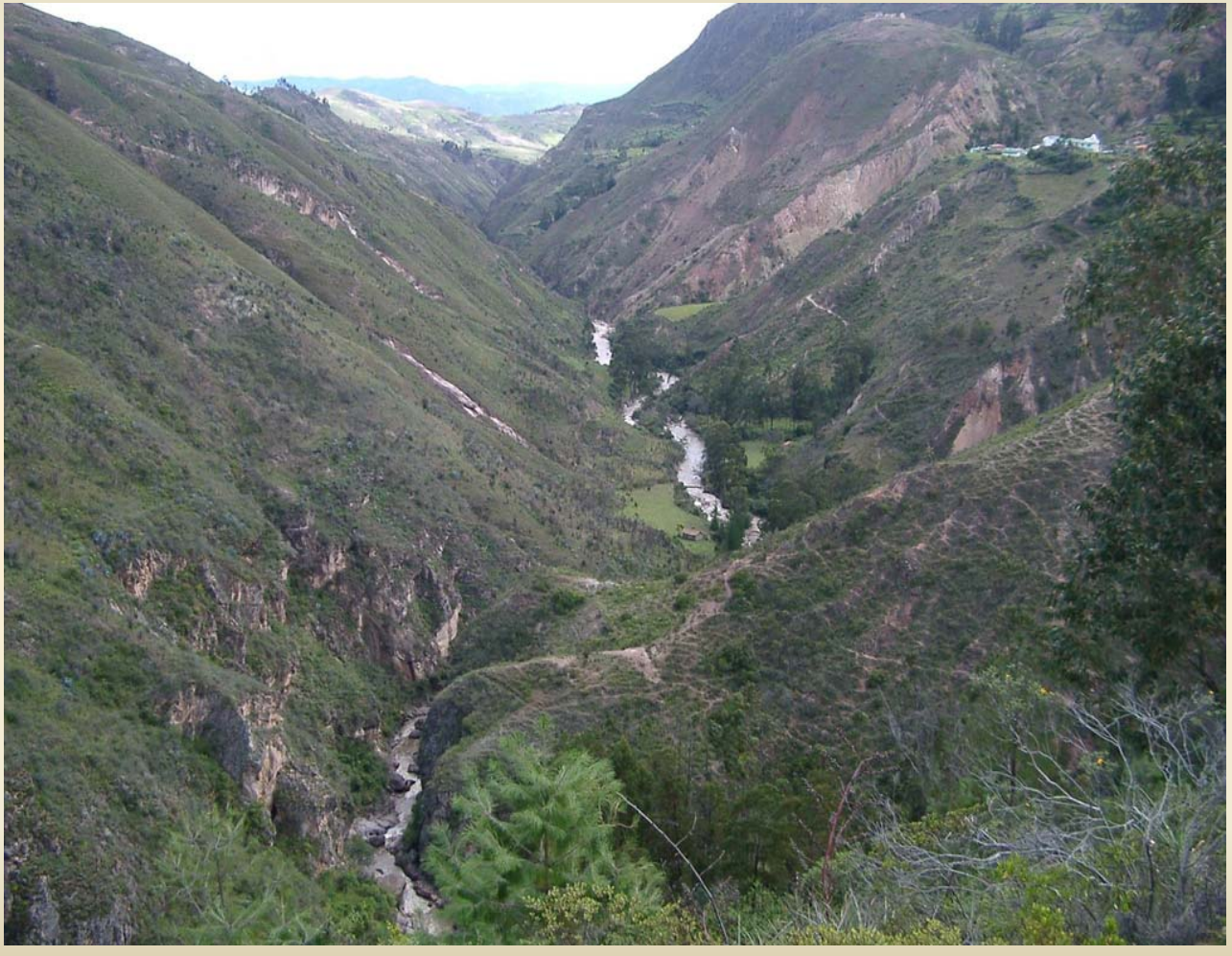
BASIC DESIGN PARAMETERS

- Head
- Design flow and degree of flow regulation
- Power demand

Variations in natural conditions

	HIGH MOUNTAINS, DEEP AND	LOW MOUNTAINS, WIDE VALLEYS	FLAT TERRAIN OR LOWLANDS
Impact downstream of powerhouse	Water flow in river similar to before	Water flow much more regulated than before	Water flow much more regulated than before

Example of river in high mountain



Hydropower schemes in high mountain regions

TYPICAL SCHEME

- High head scheme with low or moderate design flow
- Tunnels and shafts
- Underground powerhouse with Pelton or Francis turbine
- Low dam(s) to divert flow through tunnel
- Ungated spillway, type overflow over dam
- Concrete dam

PROBLEMS

- Difficult access
- Regulation limited due to need of high and costly dams
- Unstable slopes
- Flash floods move material
- Geology of long tunnels

Hydropower schemes in lower mountain regions

TYPICAL SCHEME

- Medium head scheme
- Reservoir for flow regulation
- Reservoir close to or away from power plant
- Tunnels and/or canals according to dam and powerhouse location
- Underground or open-air power station
- Francis turbine
- Dam type according to scheme layout

PROBLEMS

- Creation of reservoirs from an environmental view
- Various

Hydropower schemes in flat terrain or lowlands

TYPICAL SCHEME

- Low head scheme
- Limited reservoir volume
- Reservoir directly in connection with a power plant
- Dam type according to scheme layout
- Open-air power station with Kaplan or bulb turbine

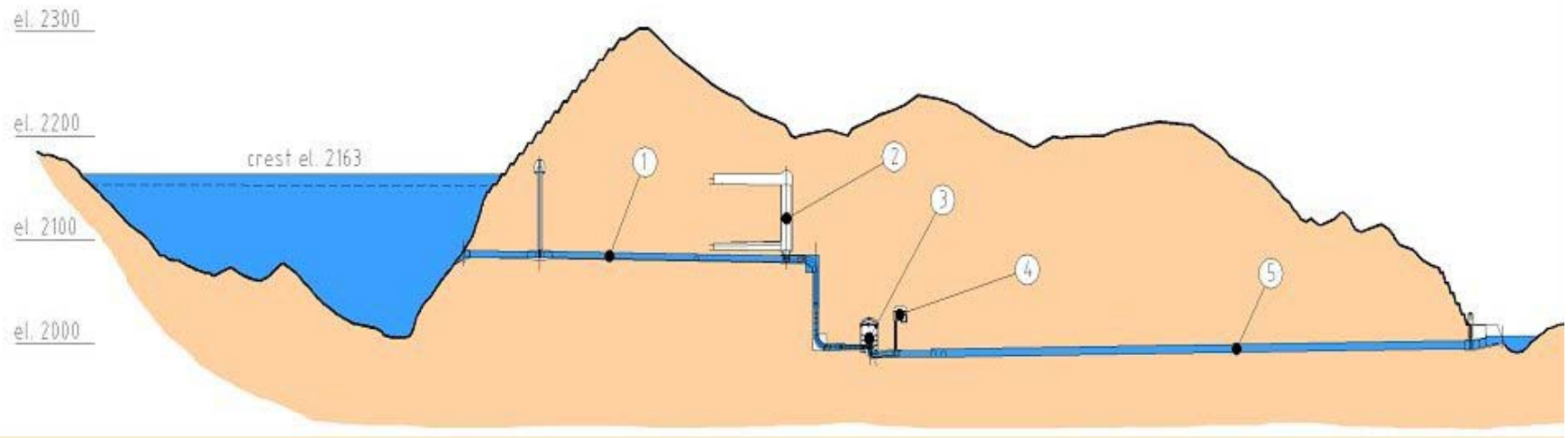
PROBLEMS

- Large areas required for reservoir due to small water depth
- Environmental aspects
- Various

Types of Turbines for different heads

For heads within the range of	Type of turbine
200-2000 m	Pelton
30- 600 m	Francis
less than 60 m	Kaplan
less than 18 m	Bulb turbine
less than 3 m	Water wheel

Underground power station
Paute Mazar, Ecuador



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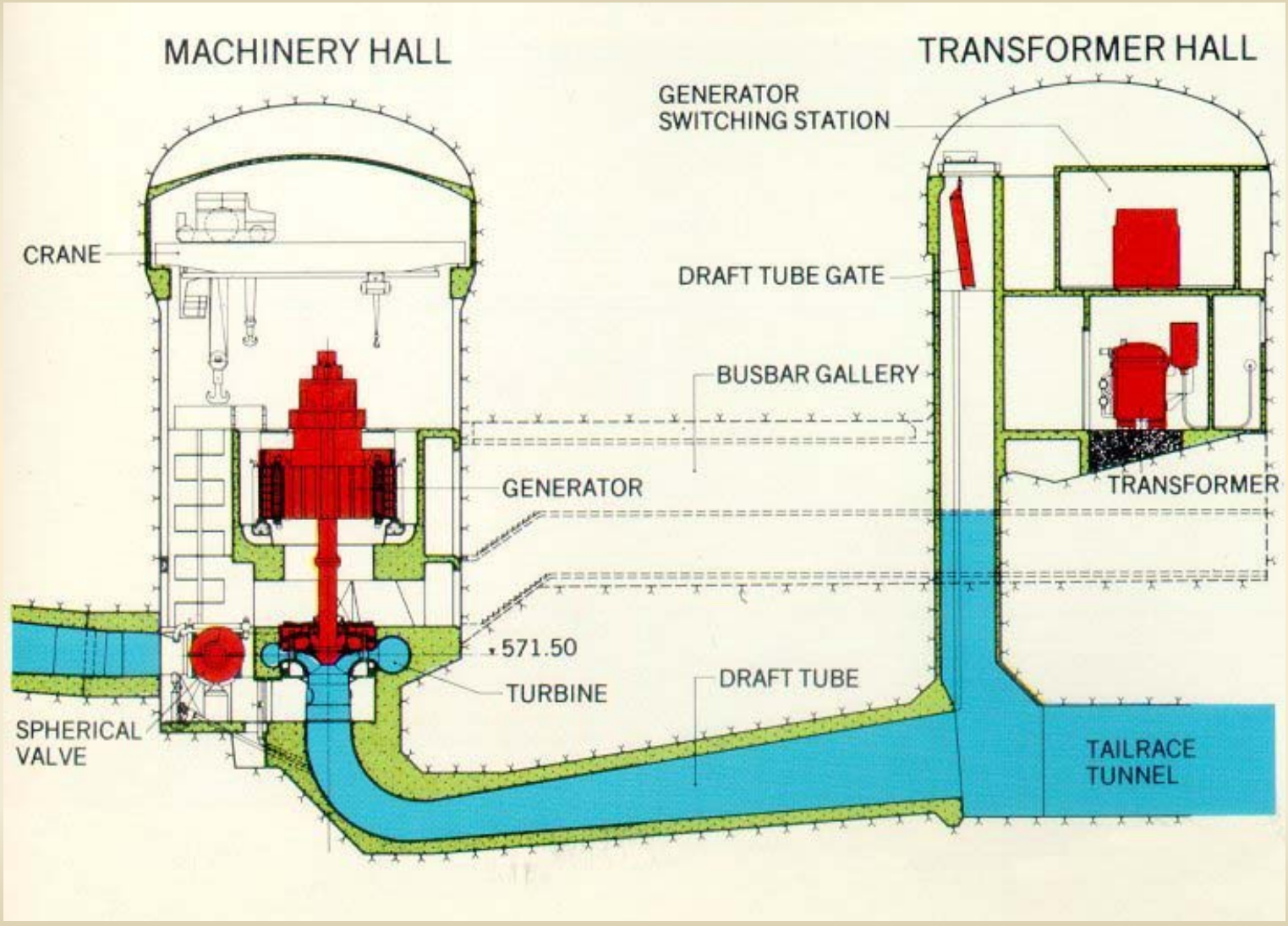
Underground Power Station



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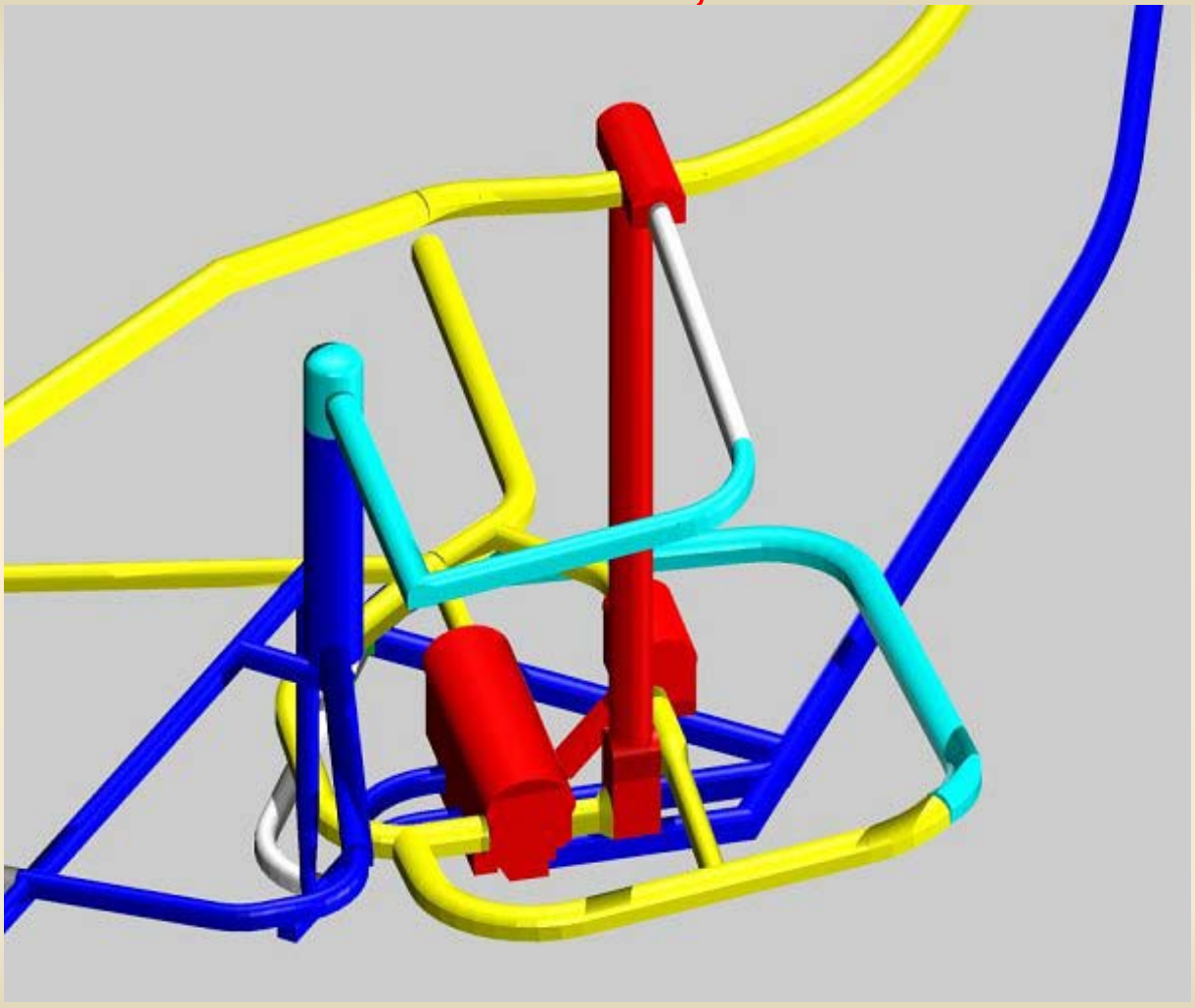
Paute Mazar Power Station, Ecuador



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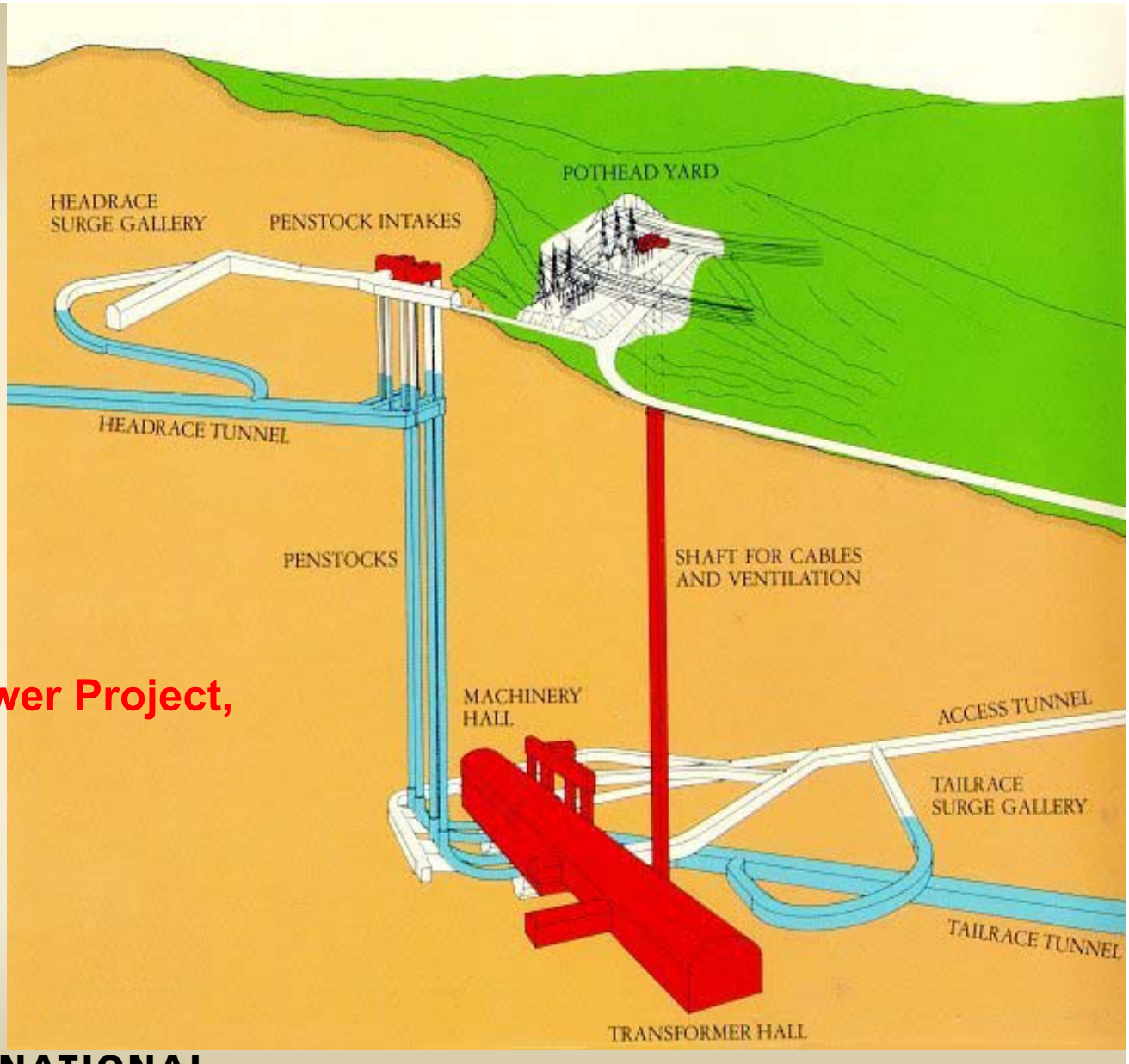
Underground Power Station

Kidatu Hydropower Project, Tanzania



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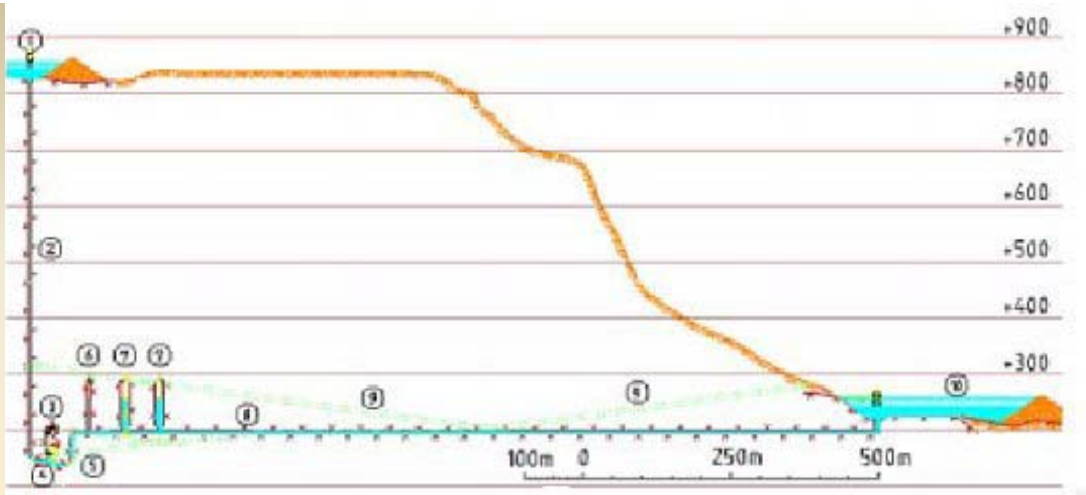
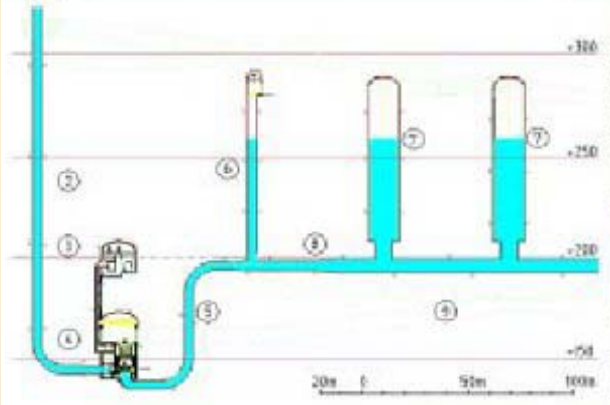
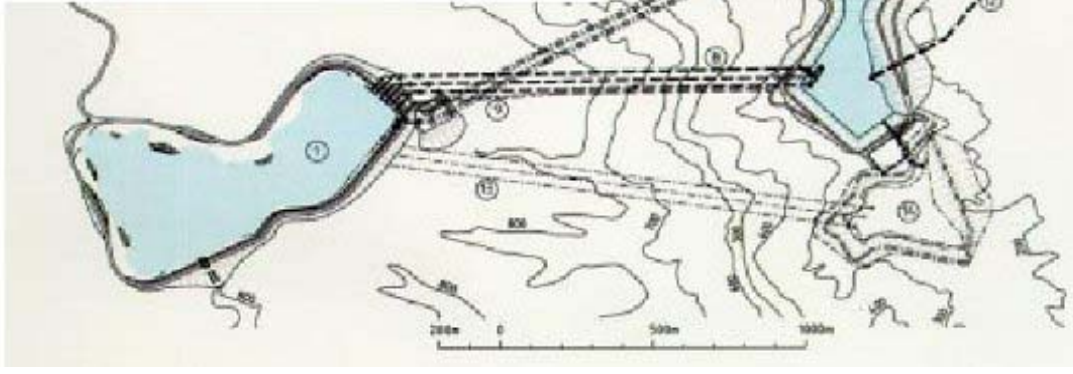
Mount Ataqua, Pumped Storage Project, Egypt







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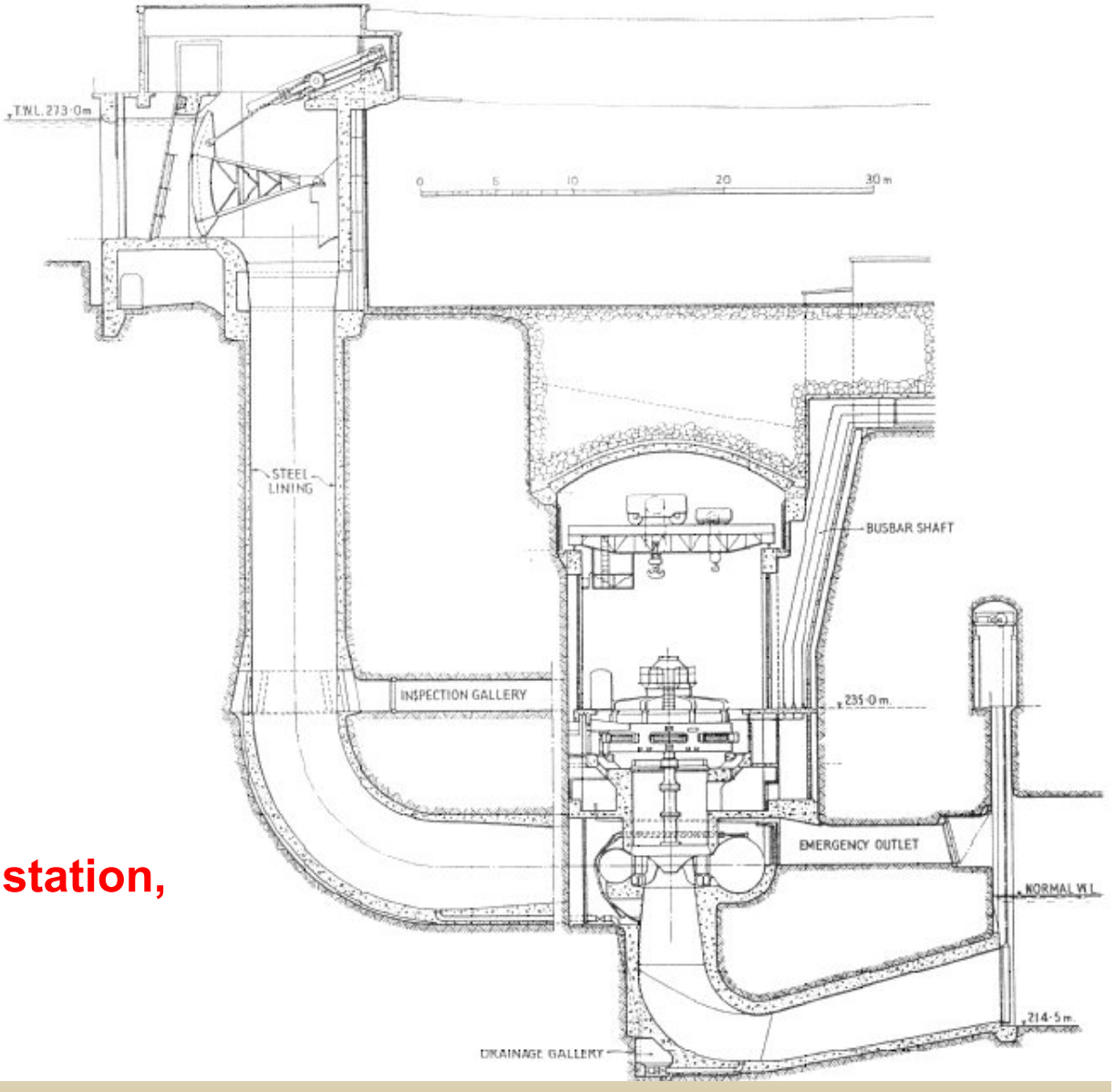
Cut and Cover Station



Section through

Storfinnforsen power station,

Sweden

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Advantages with underground schemes

- Integral part inside the rock of the water conveyance system when tunnels and shafts are used
- Avoids installation of penstock tubes on steep and potentially unstable slopes and high cutslopes for open-air powerhouse
- Good possibilities to cope with great variations in tailwater level
- Limited impact on environment
- Good protection against action of war, sabotage, landslides etc.
- Competitive costs, reduced concrete volumes
- Excavated rock can be used for dam fill
- Construction work fairly independent of climate conditions

Open-air power stations

- power stations with the power house connected to the intake by penstocks or tunnels
- power stations with the power house located at the toe of a dam
- integral power stations

Saymirin Power Station, Ecuador

Pelton turbines

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Penstocks and powerhouse
Song Hinh, Vietnam

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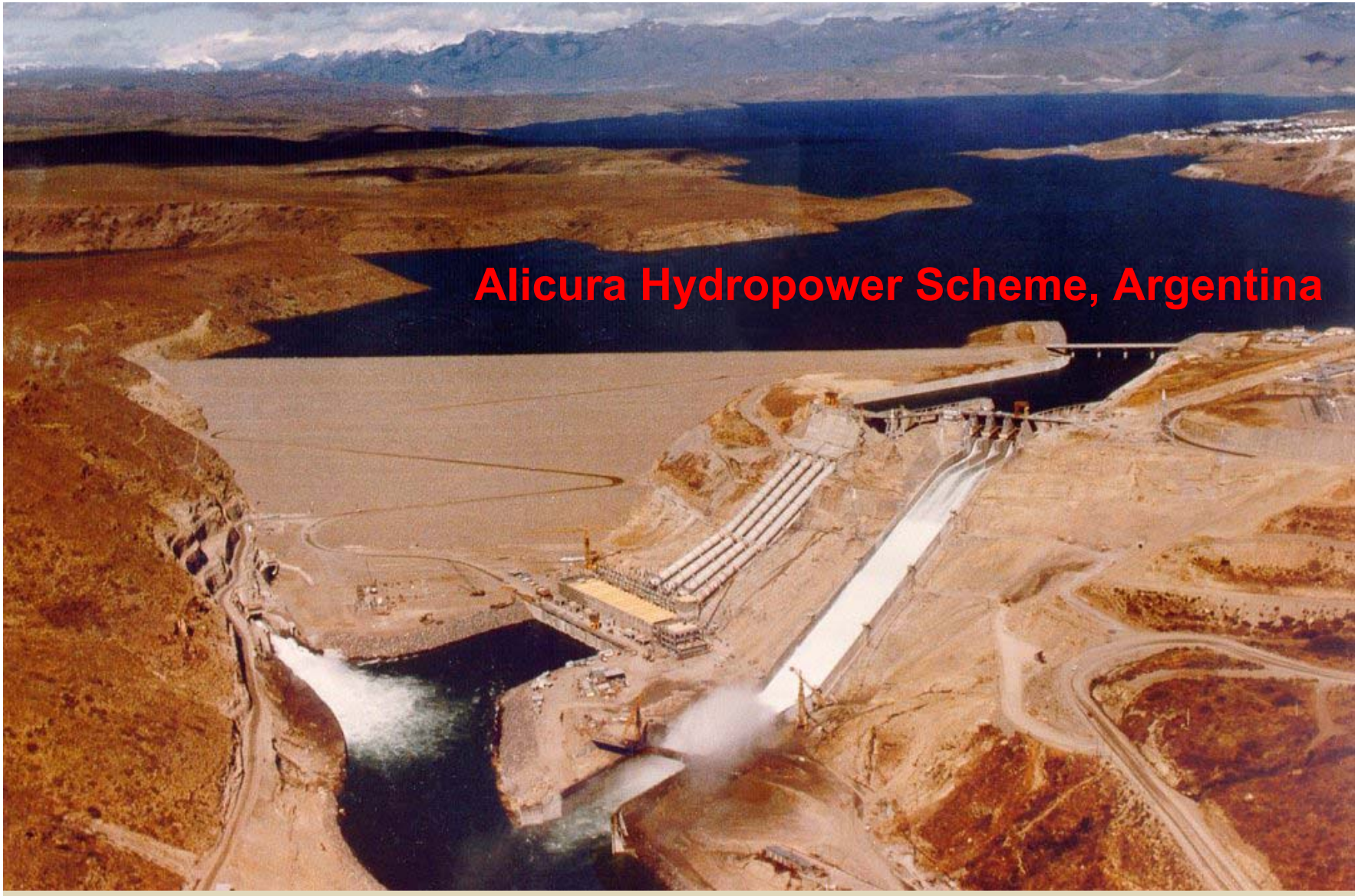

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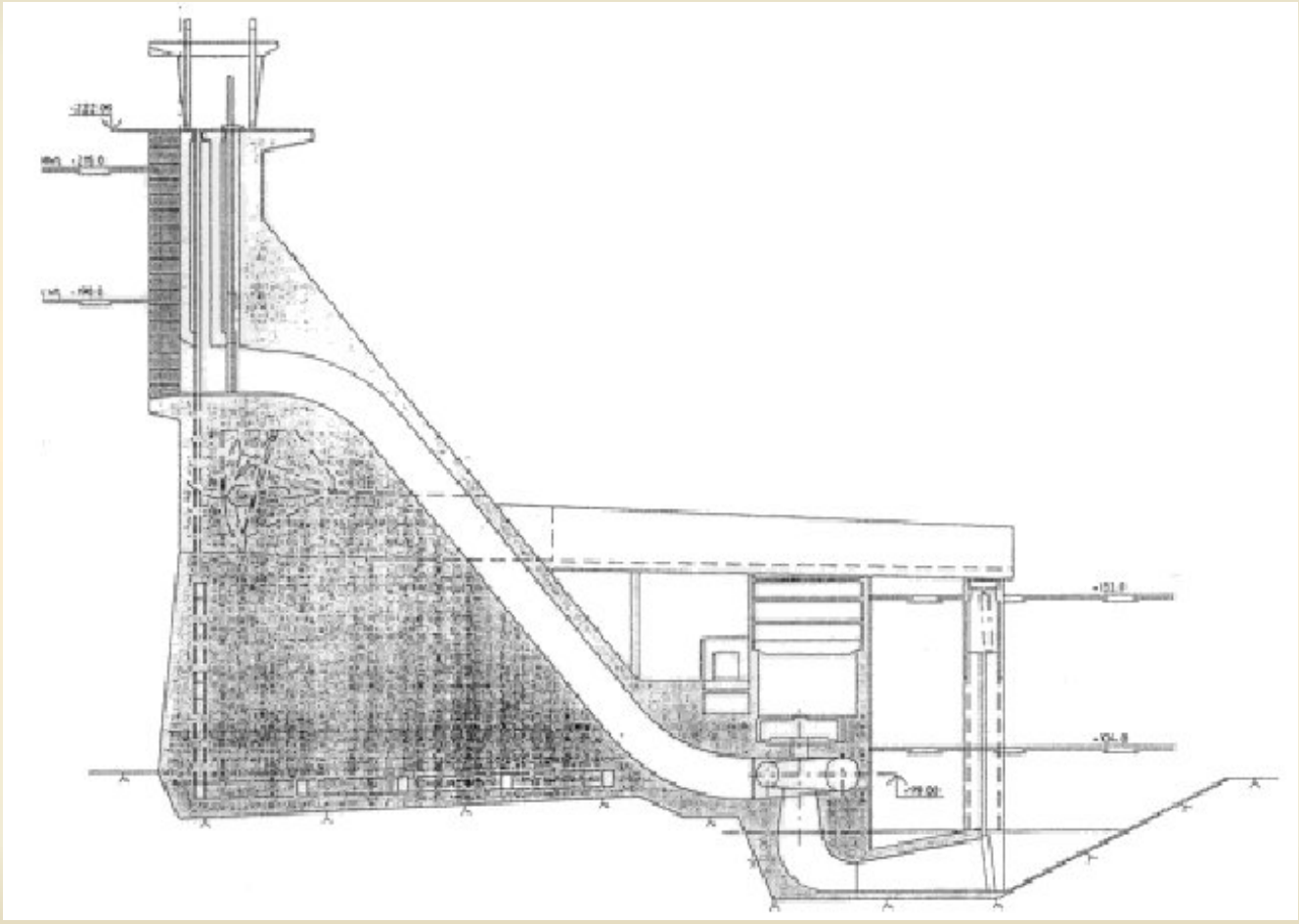
Power station at toe of dam
Son La Hydropower Project, Vietnam



SON LA HYDROPOWER PROJECT
ALTERNATIVE II
CONCRETE GRAVITY DAM AT TA BU (HWL +215M)

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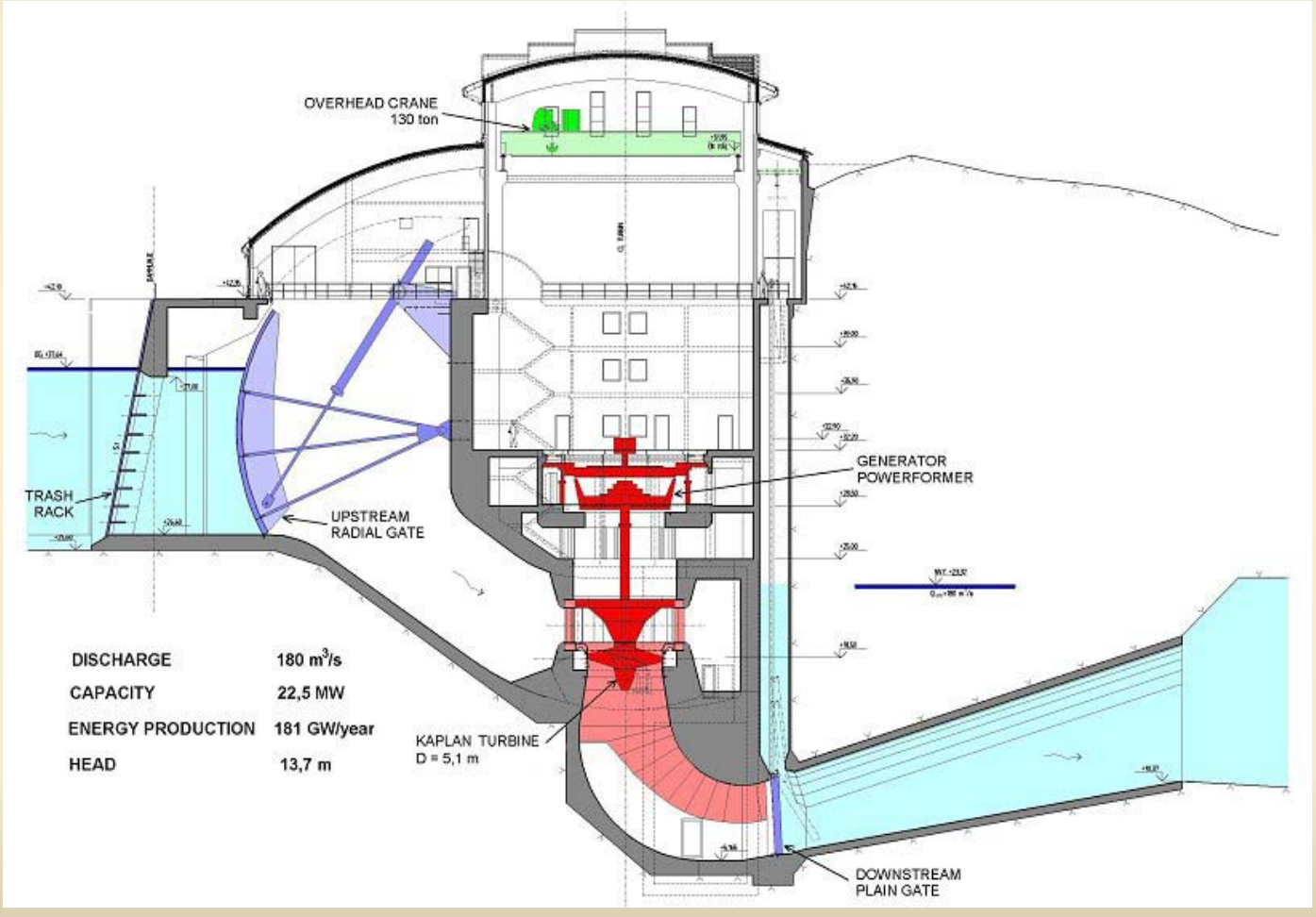
Integral type power station

Höljebro Hydropower Project, Sweden



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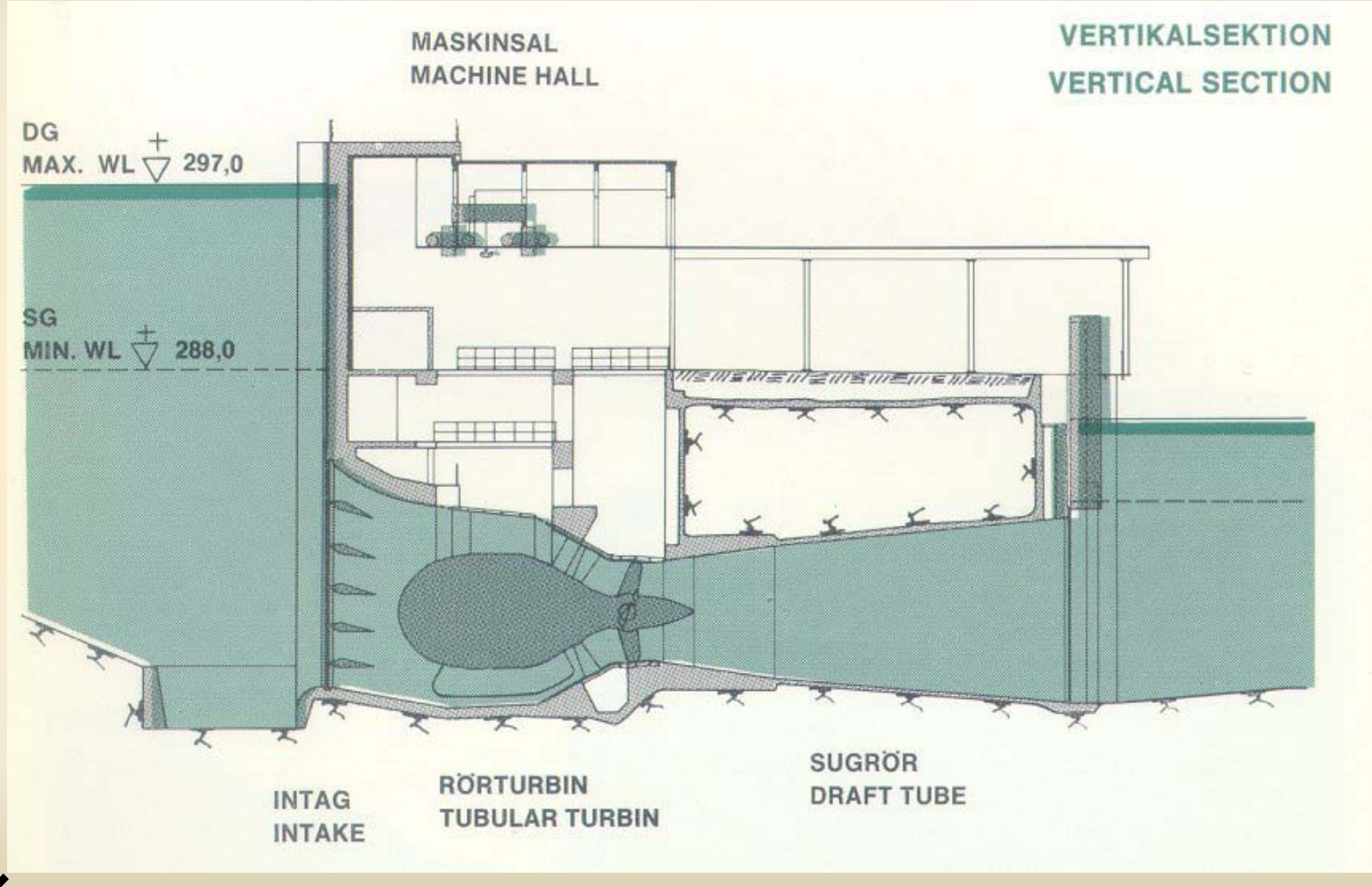
Power station with Bulb turbine



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Small-Scale Hydro power

- a low dam
- a tube intake
- a tube made of wood, plastic, concrete or steel
- an open-air power station
- a tailrace channel

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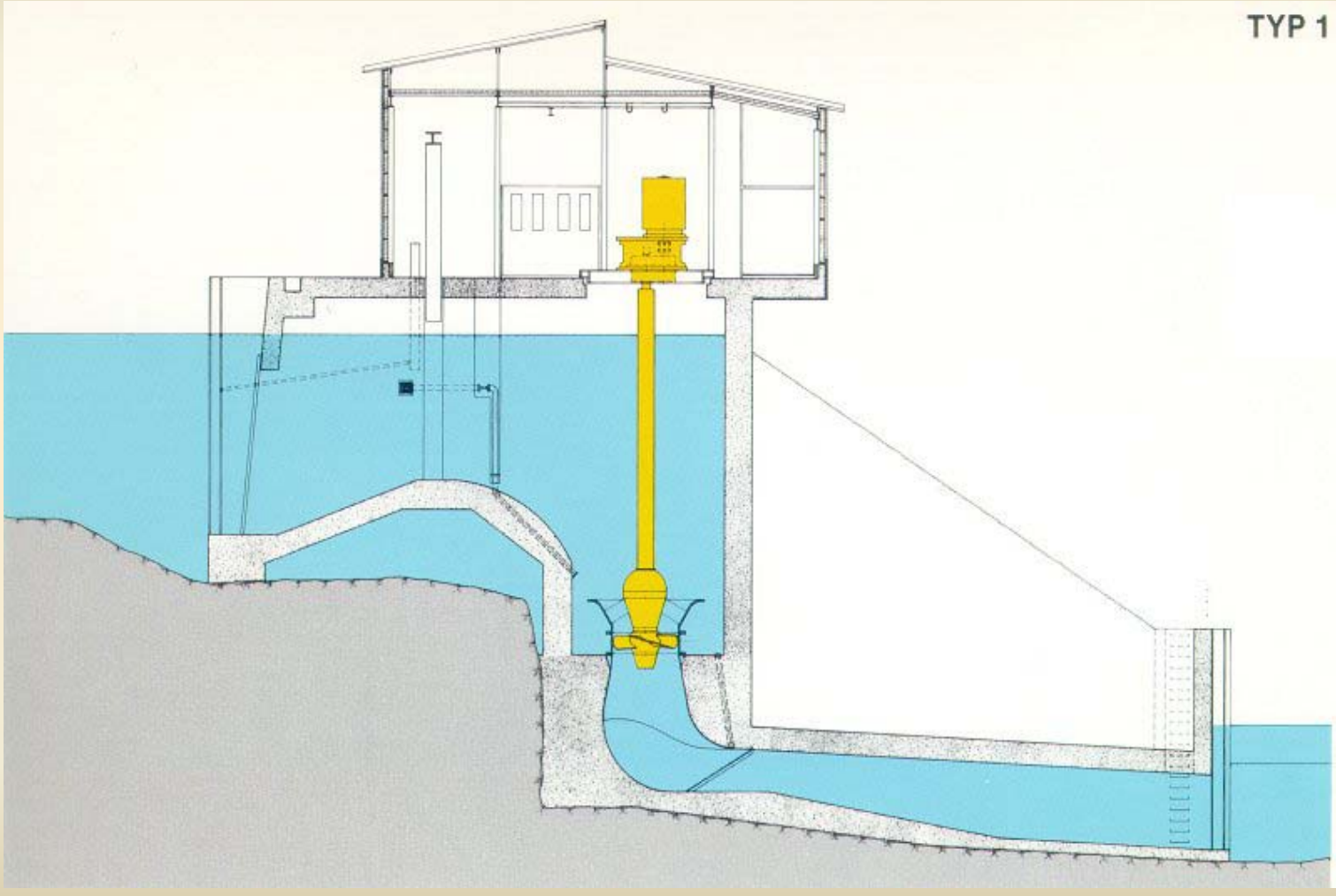
Small-Scale Hydro Power – Type 1



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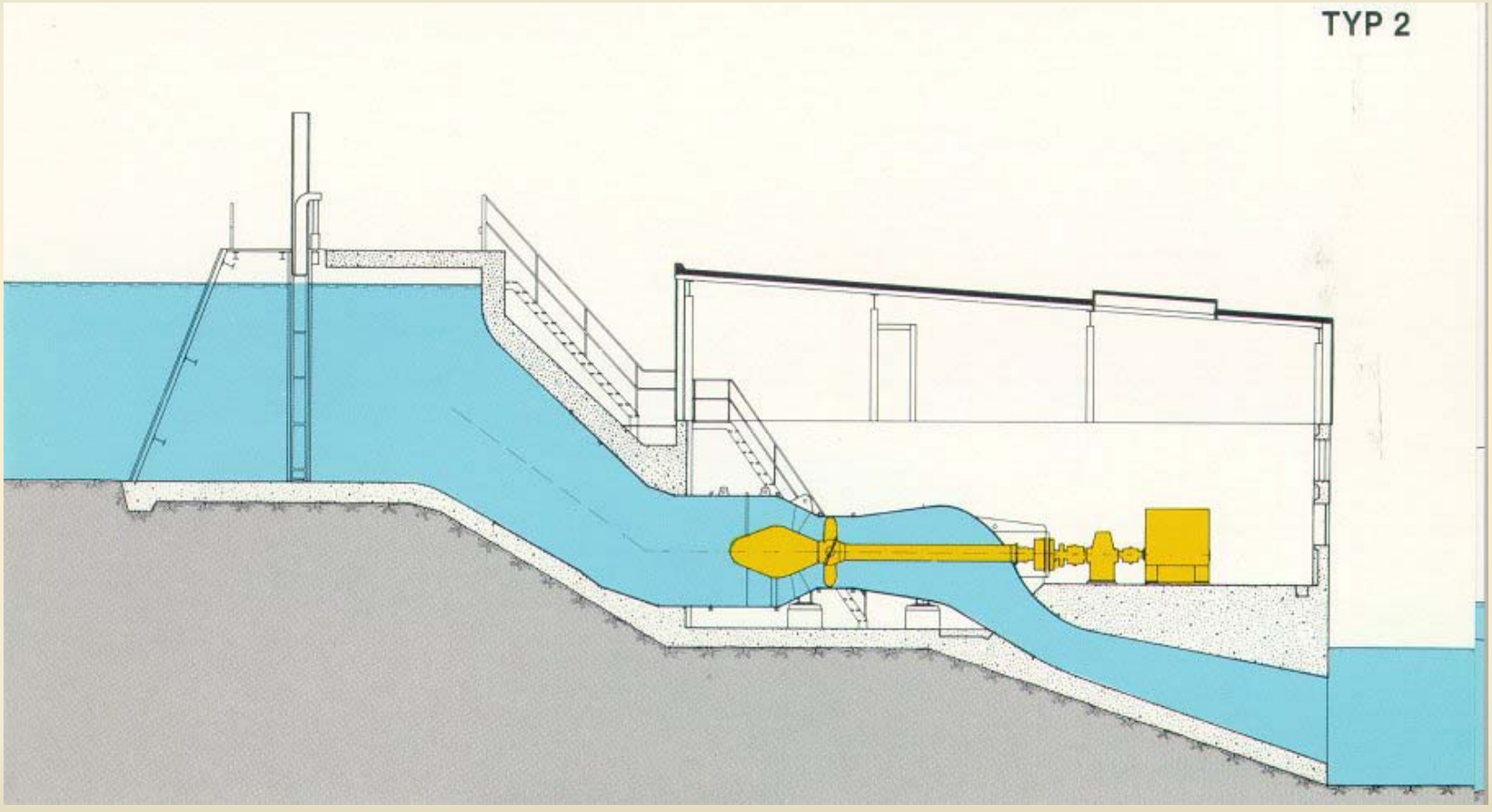
Small Scale Hydro Power – Type 2



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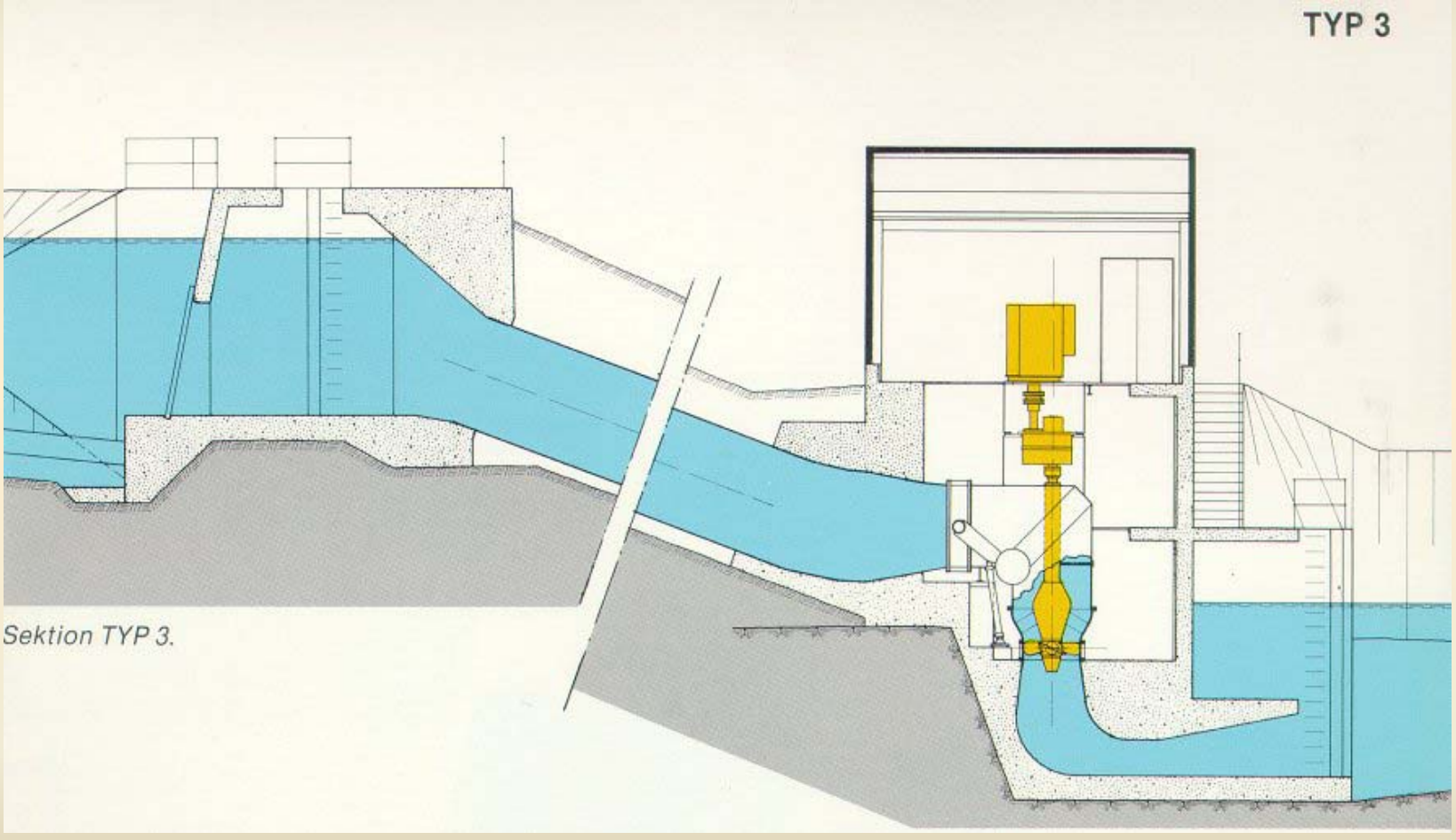
Small Scale Hydro Power – Type 3



Sektion TYP 3.

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Purpose of dams for hydropower

- to divert the water in a river into the power station
- to concentrate the head available over some length of the river
- to create a reservoir to regulate the river flow to meet with the variations in demand of energy

Other purposes of dams

- water supply of municipalities and industries
- irrigation of cultivated land
- flood storage
- river navigation by dams with locks

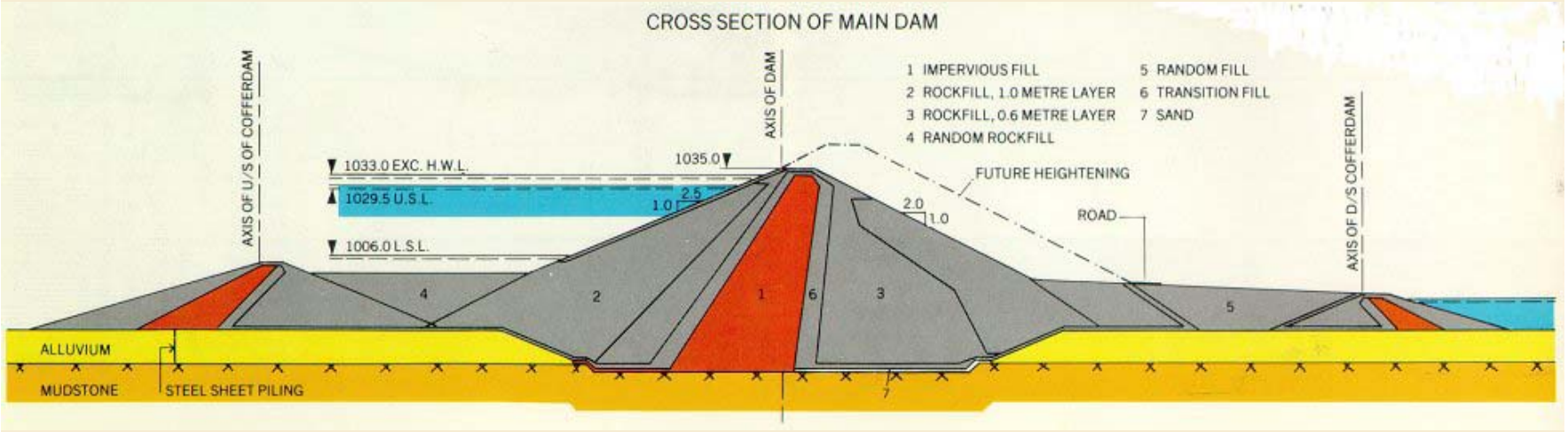
Types of dam

- embankment dams
- concrete gravity dams
- arch dams

Influencing Factors on Choice of Dam Type

- size and purpose of the dam
- spillway incorporated or not in the dam body
- spillway type (gated or ungated) and capacity
- topographical conditions
- geological and geotechnical foundation conditions
- seismological conditions
- availability of construction material
- overtopping of the dam, for example due to large slides in the reservoir

Itezhitezhi Dam, Zambia



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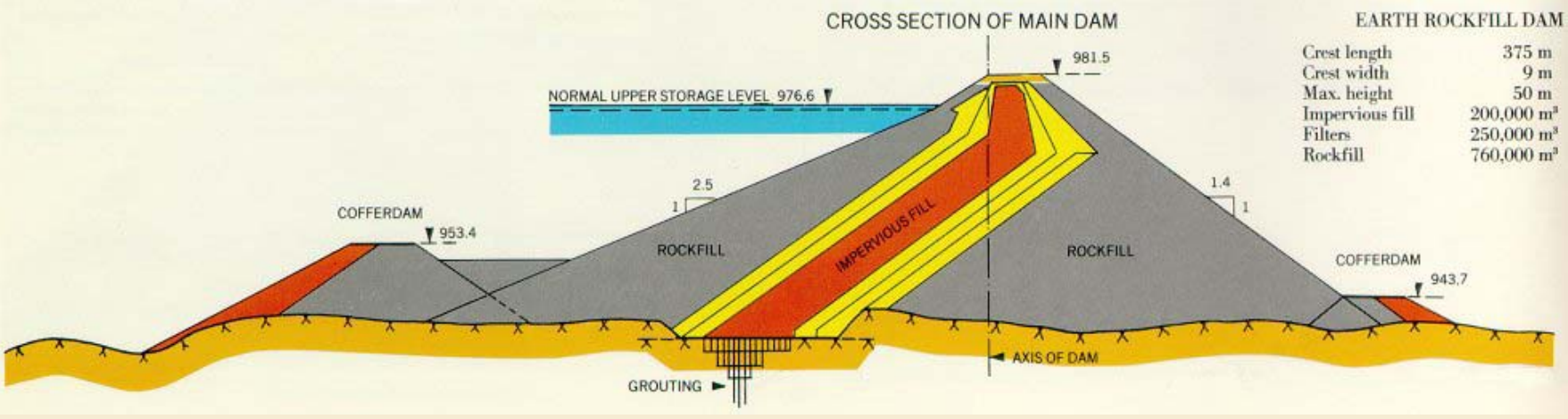
Embankment dam with core of impervious fill



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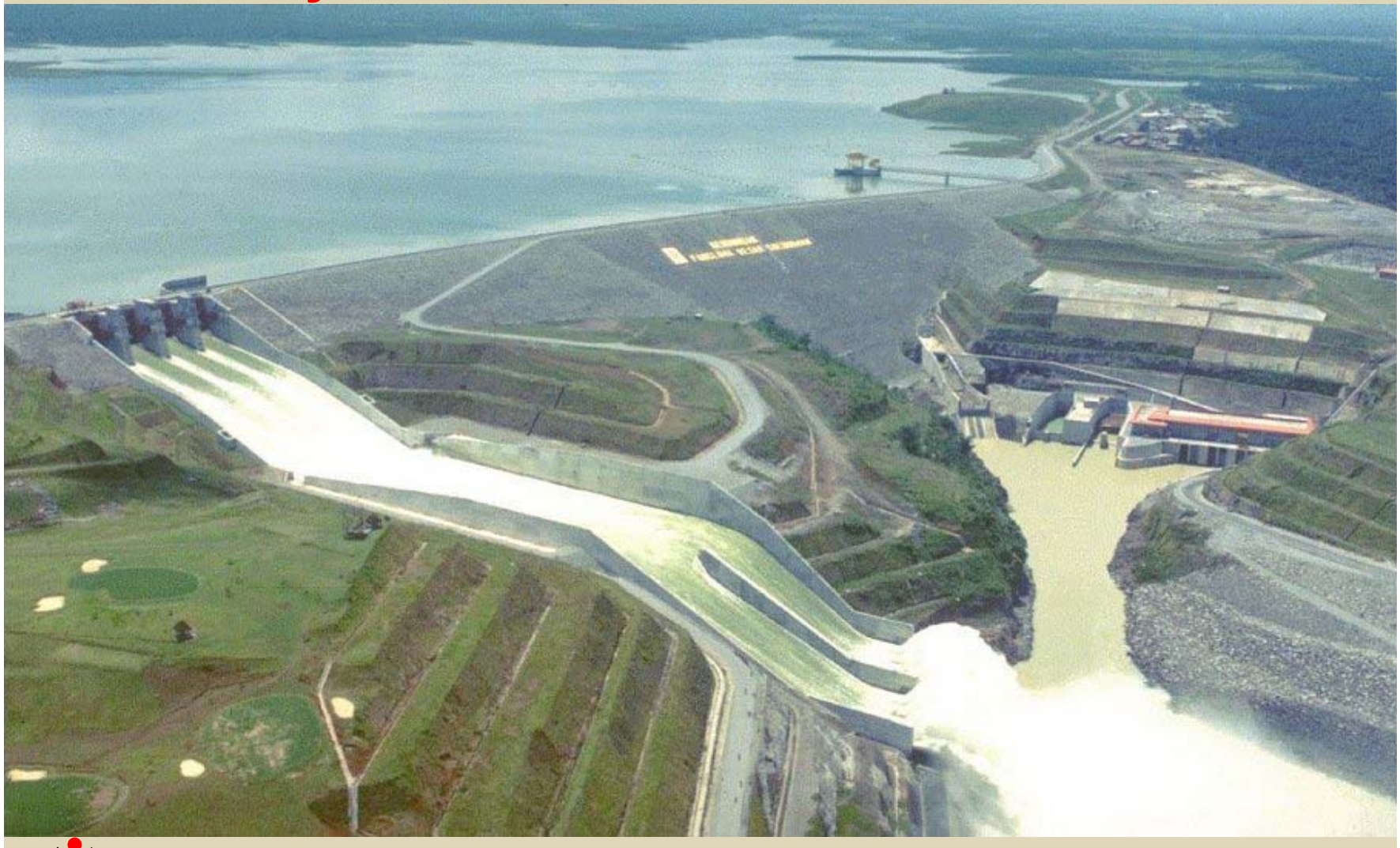
Mrica Hydroelectric Power Plant, Indonesia



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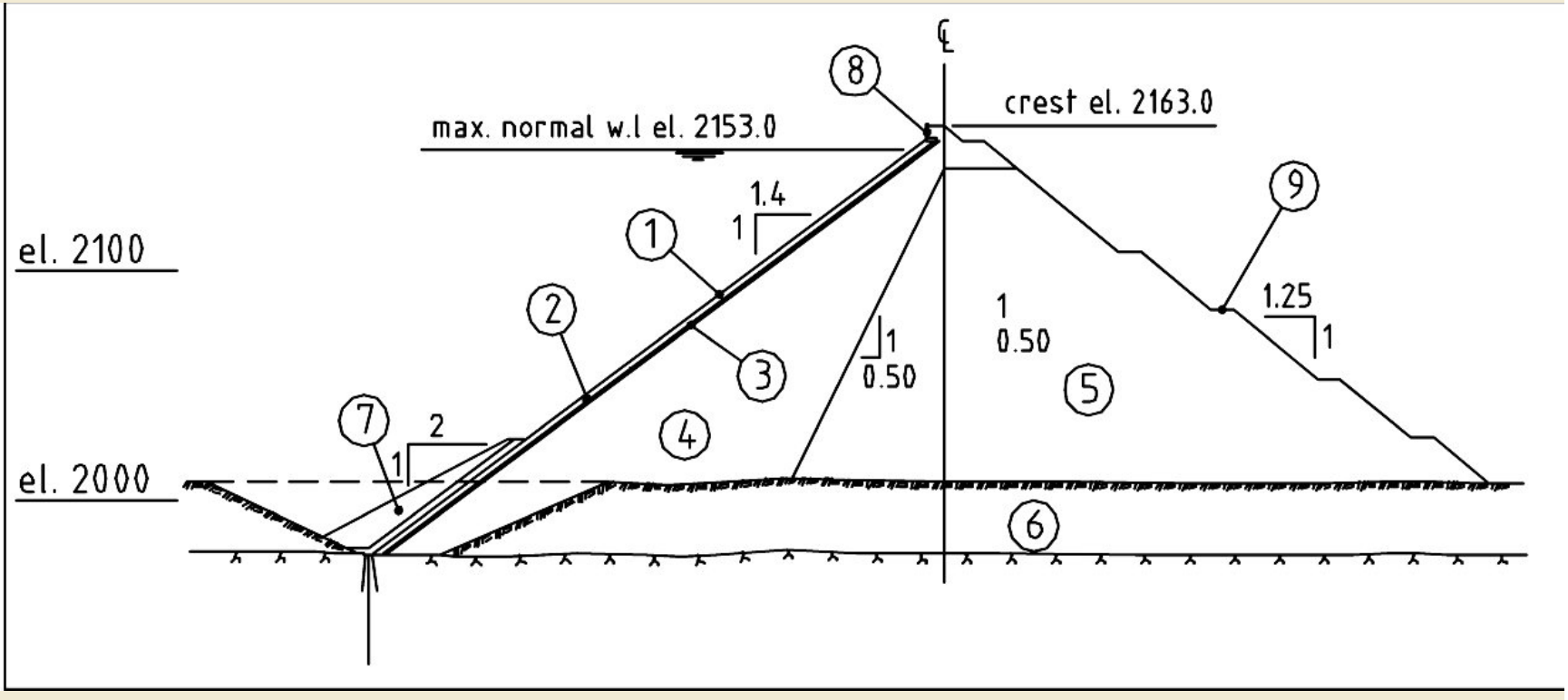
Concrete Faced Rockfill Dam CFRD – Typical section



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CFRD during construction

Barrigón Dam, Panama

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CFRD Esti Hydropower project, Panama

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CFRD – Fortuna Dam, Panama

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Concrete Gravity Dams

CONVENTIONAL CONCRETE –

CONSTRUCTION IN BLOCKS

ROLLER COMPACTED CONCRETE (RCC)–
CONSTRUCTION IN HORIZONTAL LIFTS

- High capacity of concrete placing
- Low cement content

Concrete Gravity Dam
Chiriqui Dam, Panama

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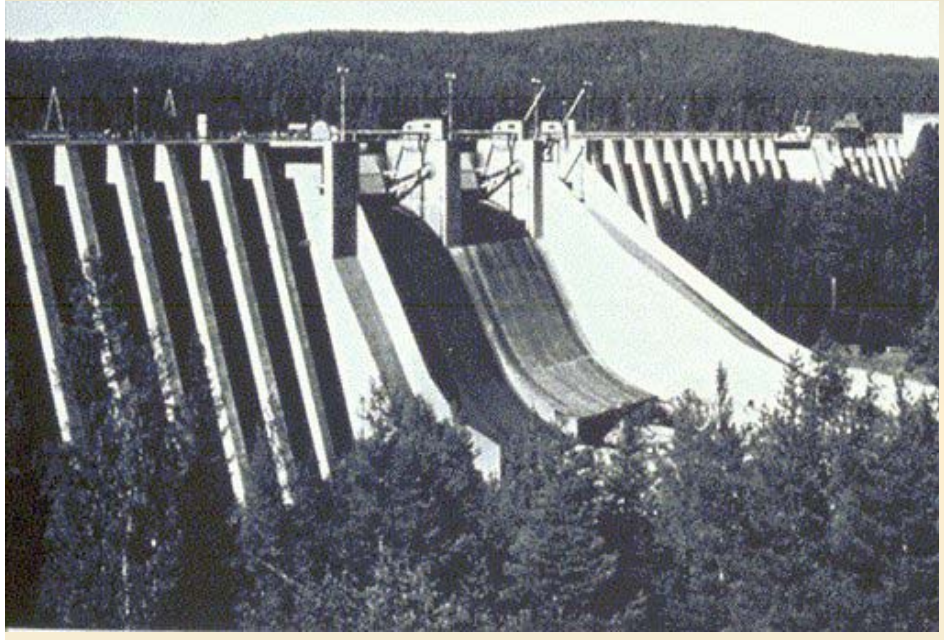
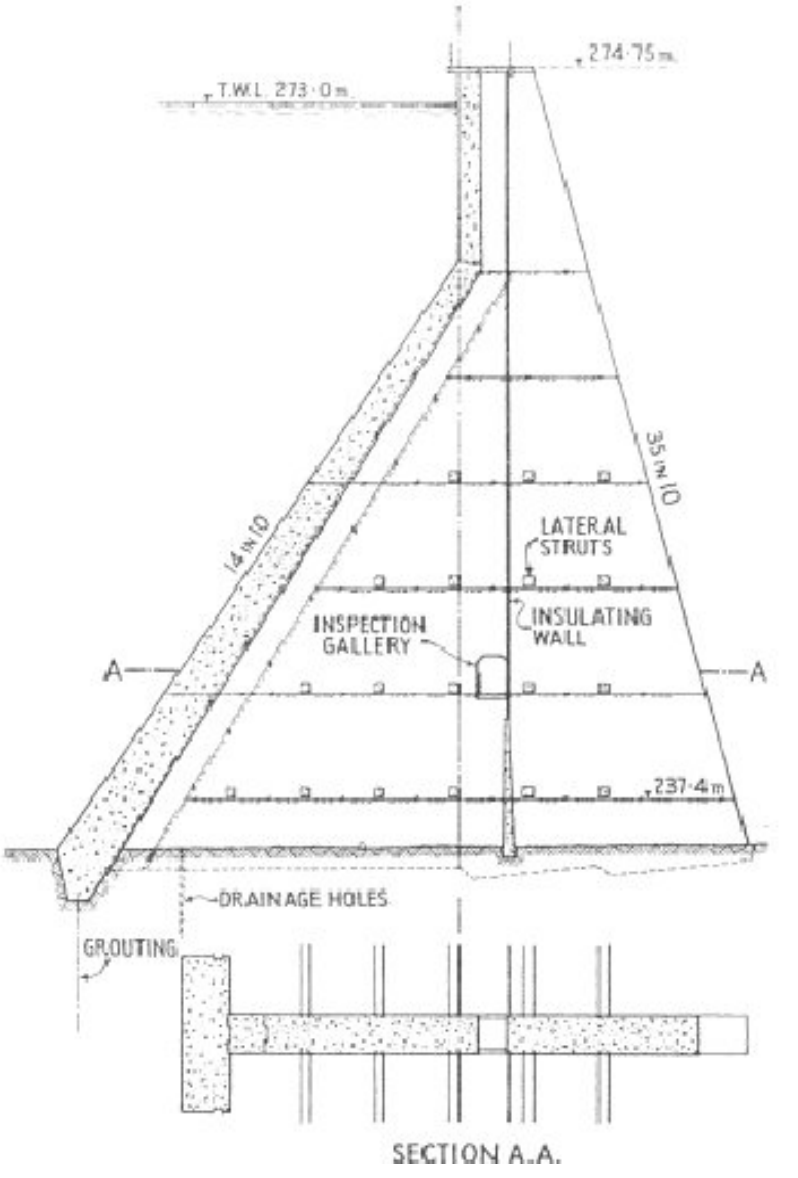
Concrete Buttress Dam

Section through buttress section of Storfinnforsen dam, Sweden





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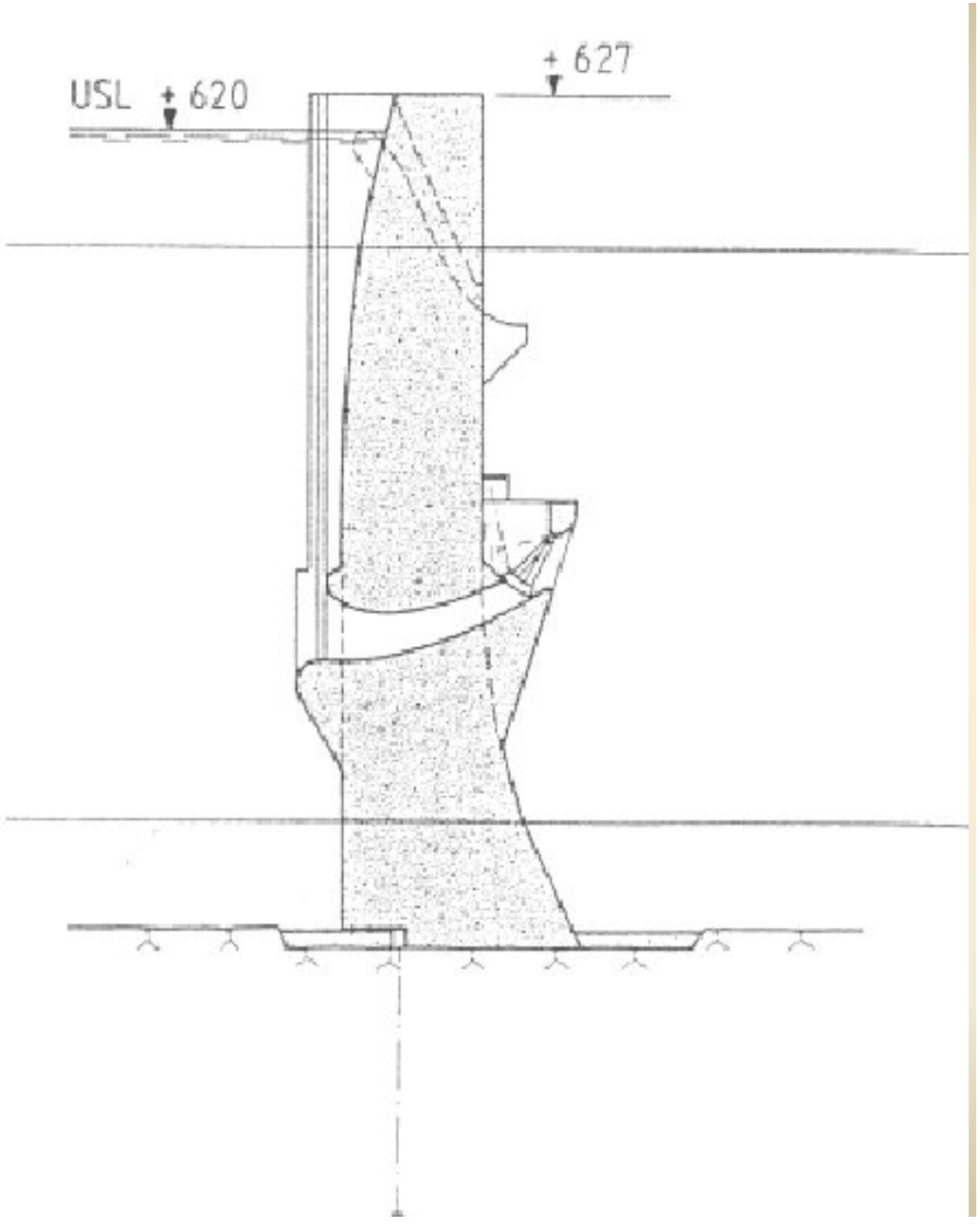
Arch dam with deep spillway openings



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The end